Multispectral Fingerprint Imaging

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Topics

- Conventional fingerprint sensing

- Multispectral imaging (MSI) overview

- Use of MSI for spoof detection

- Use of MSI for biometric enhancement
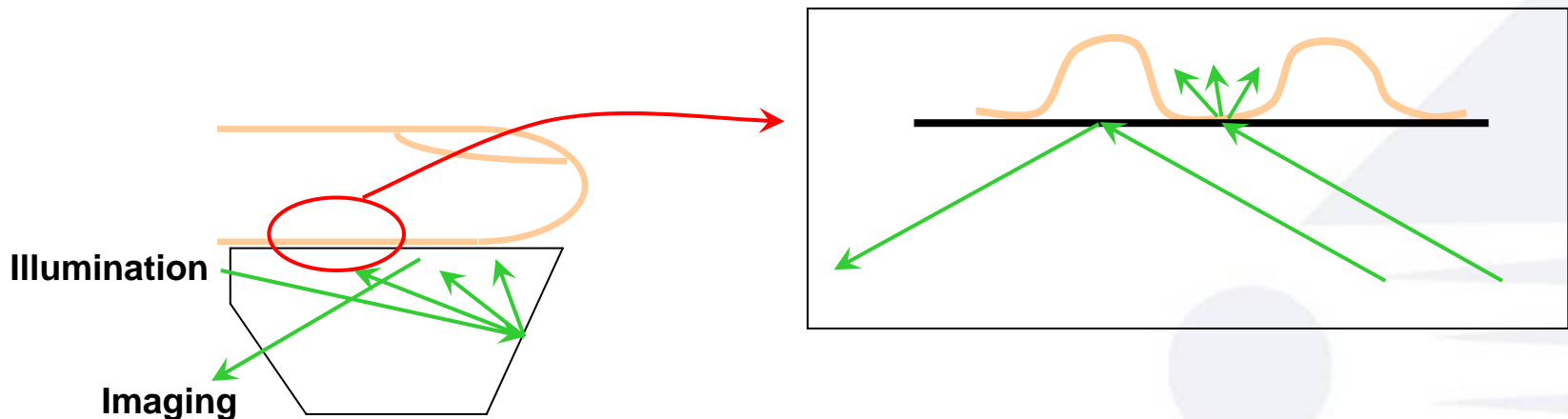
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Introduction

- One important element required for remote biometric authentication is a *sensor* capable of providing a <u>high assurance of identity</u> while maintaining a <u>high degree of usability</u>

  - Minimum requirements for strong identity assurance:

    - Accessible biometric with a high degree of specificity to an individual

    - Biometric sensor is resistant to spoofing attempts

  - Minimum requirements for enhanced usability:

    - Sensor able to be used across the range of common physiological and environmental conditions

    - Human-sensor interface is intuitive and simple

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Background
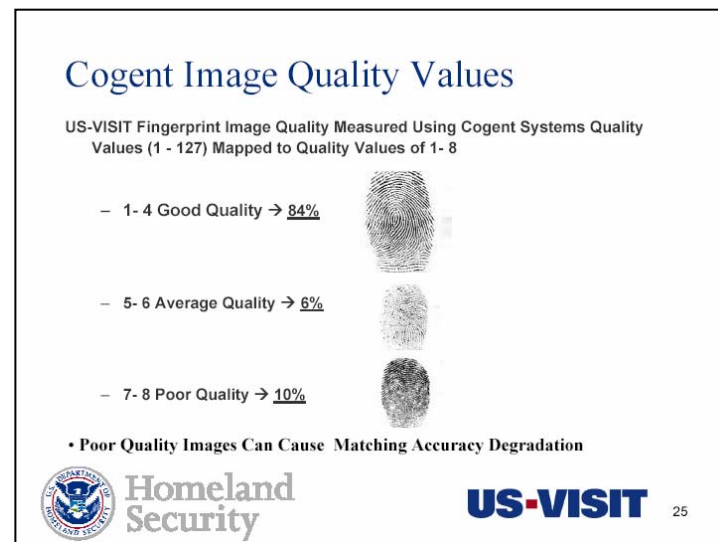# Conventional Fingerprints Sensors

- Most fingerprint sensors measure skin features at, or very near, the surface of the finger
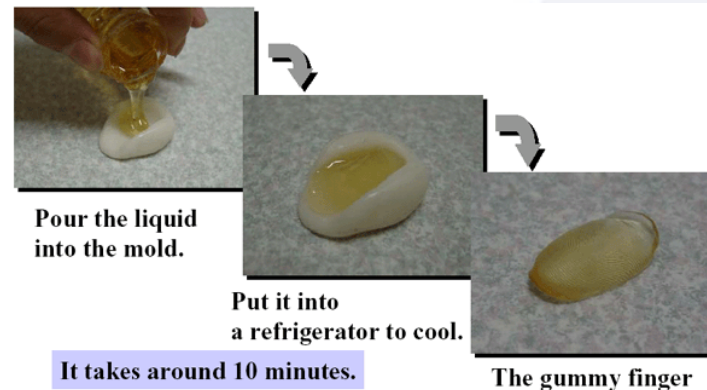 - Example: optical frustrated total internal reflectance (TIR)

Illumination

Imaging

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- **Poor quality prints degrade system accuracy and cause delays and user frustration**
  - Dry skin
  - Wet skin
  - Poor contact
  - Poorly defined fingerprint features

- **Current fingerprint sensors are susceptible to "spoofing"**
  - Silicone, latex, gelatin

Cogent Image Quality Values

US-VISIT Fingerprint Image Quality Measured Using Cogent Systems Quality Values (1 - 127) Mapped to Quality Values of 1- 8

- 1- 4 Good Quality → 84%
- 5- 6 Average Quality → 6%
- 7- 8 Poor Quality → 10%

• Poor Quality Images Can Cause Matching Accuracy Degradation

Homeland Security

US·VISIT   25

www.biometrics.org/bc2004/Presentations/Conference/1%20Monday%20September%2020/
Mon_Ballroom%20E/4%20DHS%20Session/Latta_update.pdf

Pour the liquid into the mold.

Put it into a refrigerator to cool.

It takes around 10 minutes.

The gummy finger

www.blackhat.com/presentations/ bh-usa-02/bh-us-02-smith-biometric.ppt

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Multispectral Imaging (MSI) Overview
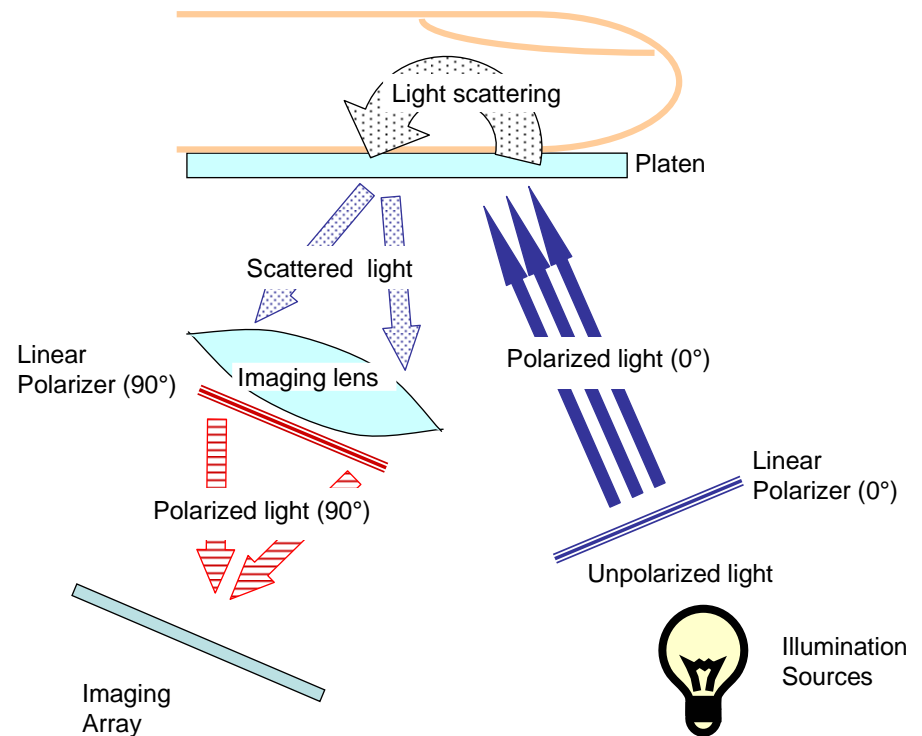# Goals and Approach

- **Goals: develop a fingerprint sensor that is <u>easy to use</u> *and* <u>hard to spoof</u>**
  - Doesn't require specific skin characteristics
  - Doesn't require precise contact
  - Sensor collects multiple skin characteristics, which can be used to …
    - … provide strong spoof protection
    - … provide additional biometric information beyond just the fingerprint

- **Approach: Collect multicolor images of internal and external features of the skin**
  - Multispectral imaging (MSI)
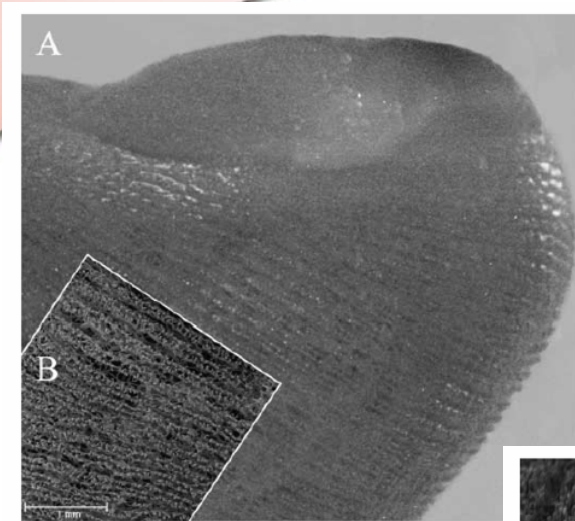
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MSI Overview
System Description

- Customized multispectral imager:
  - Optical geometry laid out image subsurface skin
    - Avoid critical angle phenomena. Interrogate the skin, not the interface between the skin and sensor
  - Use crossed linear polarizers
    - Preferential imaging of scattered (subsurface) light
  - Use multiple illumination wavelengths
   - See different depths and structures in the tissue

Light scattering

Platen

Scattered light

Linear Polarizer (90°)

Imaging lens

Polarized light (0°)

Linear Polarizer (0°)

Polarized light (90°)

Unpolarized light

Imaging Array

Illumination Sources

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MSI Overview
Relevant Fingertip Physiology

From S. Sangirogi et al.,
"Microvascularization of the human digit as studied by corrosion casting," J. Anat. 204, 123 – 131 (2004)
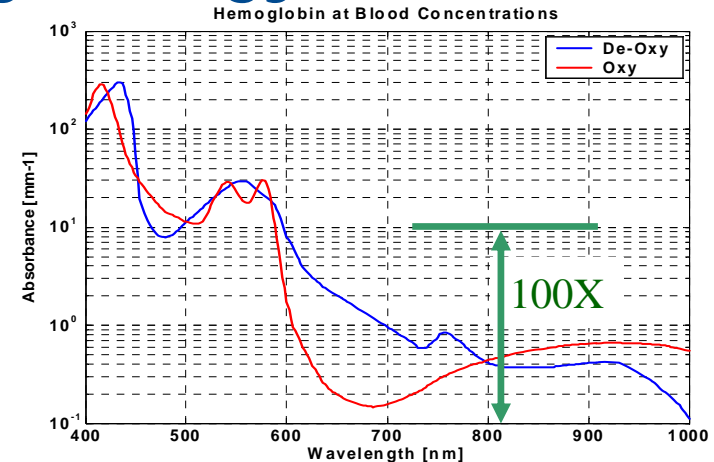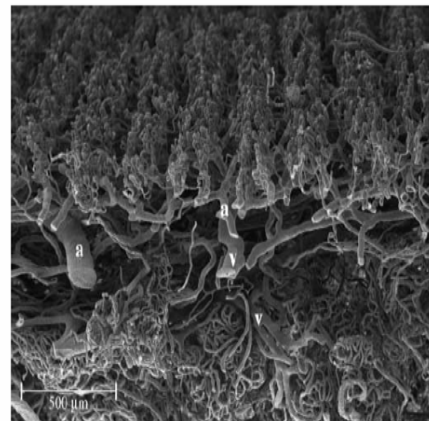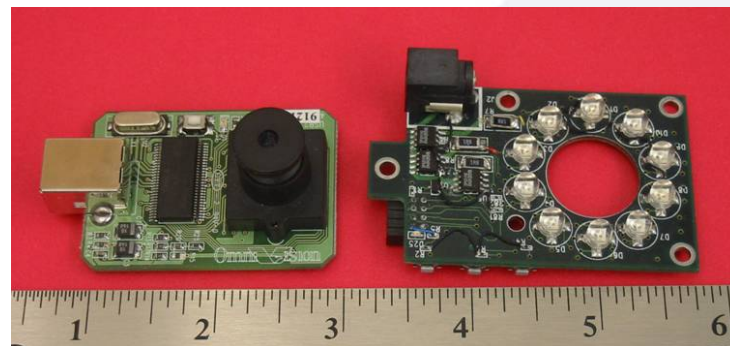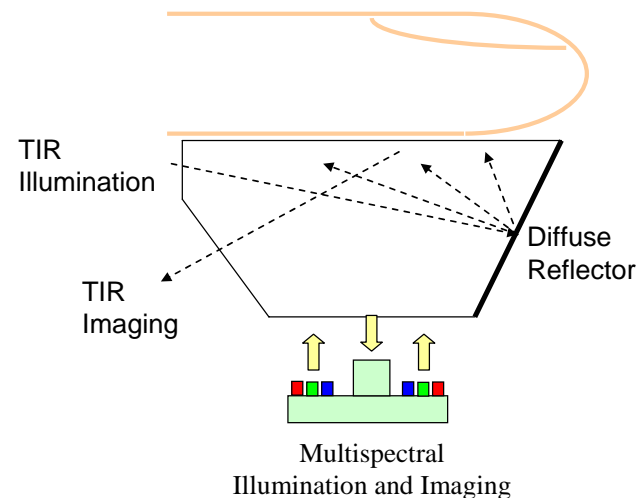

Optical absorption due to blood
(Note: semi logarithm scale)

- The structure of capillaries immediately below the surface mirrors external epidermal ridges and contains other distinct features (e.g. arterioles)

- Blood has distinct and strong absorbance bands in the visible region

- An image of these capillaries represents a subsurface fingerprint

- The non-blood portions of skin also have distinct spectral characteristics
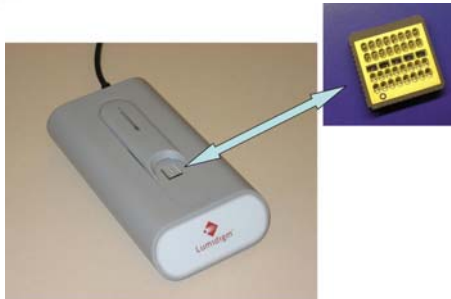
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MSI Overview
Combining with Conventional Fingerprint Technology I

- Combine total internal reflectance (TIR) and multispectral imaging (MSI) to get advantages of both

  - TIR

    - High-contrast when ideal conditions exist

    - Familiar and accepted by the user community

  - MSI

    - Low-contrast but present under a wide range of conditions

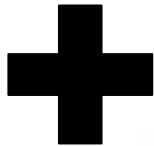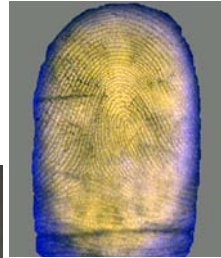   - Strong information on sample composition (spoof detection)

TIR Illumination

TIR Imaging

Diffuse Reflector

Multispectral Illumination and Imaging

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Optical skin biometric

+

Conventional fingerprint

MSI Wavelengths:
400, 445, 500, 574, 610nm + TIR Illum.

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Spoof Detection
Easy Case – Simple Silicone Casting

Data from
9 people

Data from
silicone spoof

TIR
Image made from a
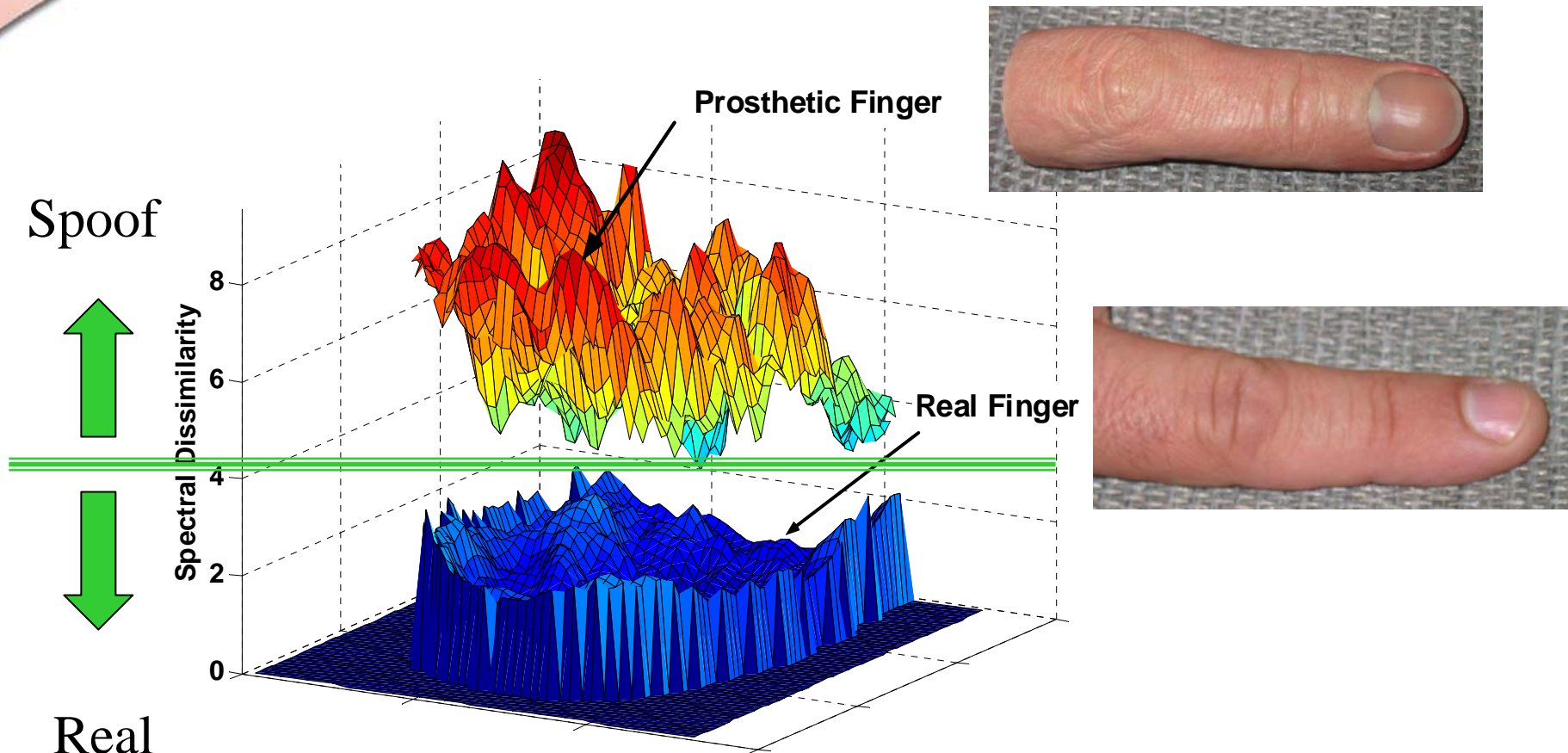silicone replica of a fingerprint
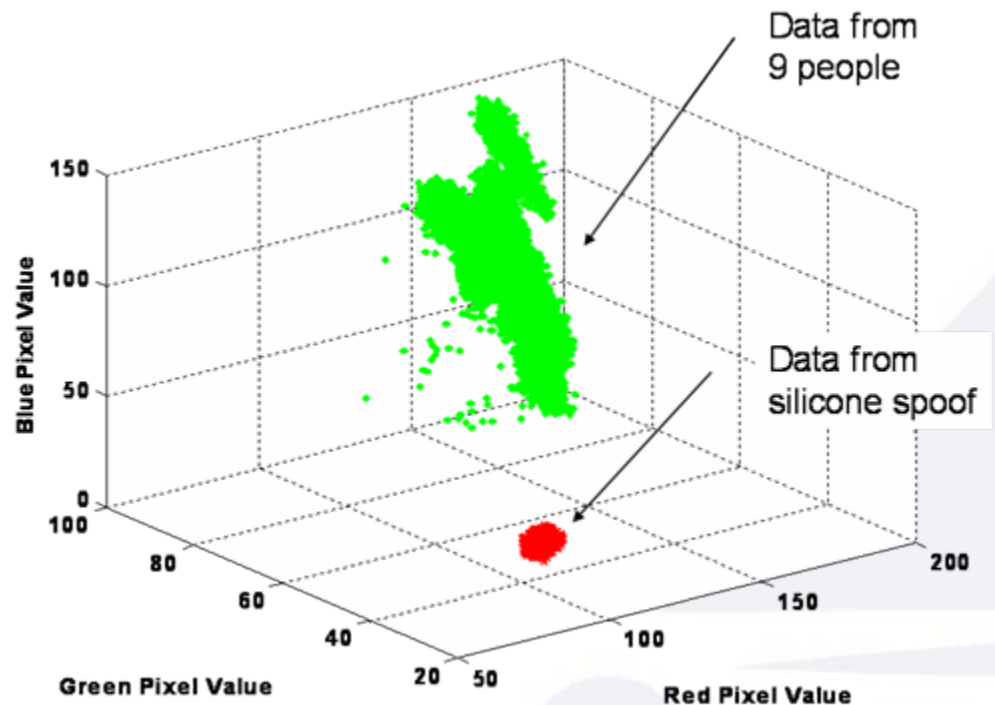
MSI
Spectral comparison of
silicone data and multiple people

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Spoof Detection
Extreme Case – High-Fidelity Silicone Model
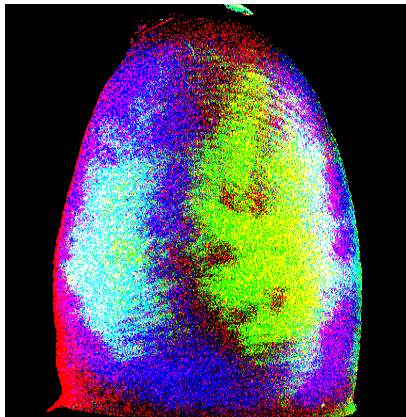
Spoof Detection
Thin Transparent Film on Skin

TIR

MSI (Average Image)

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Biometric Determinations
Typical MSI Data and Fingerprint Extraction Process

Original Image	Intermediate Image	Identifying Features
Processed and Discarded	*Processed and Discarded*	*Stored and Used for Comparison*

Colors represent internal spectral structure

Colors indicate which multispectral plane was used (Black=all)
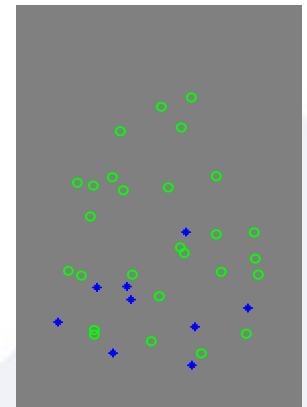
Colors represent ridge endings (green o) or bifurcations (blue *)

- Currently using commercially available fingerprint software for performance assessments
  - Neurotechnologija

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Comparison of TIR and MSI Images
Good Quality Finger

Raw Image

Binary Image

TIR

MSI

3 planes
mapped to
RGB

Equivalent fingerprint features,
but MSI can see beyond the region of contact

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Comparison of TIR and MSI Images
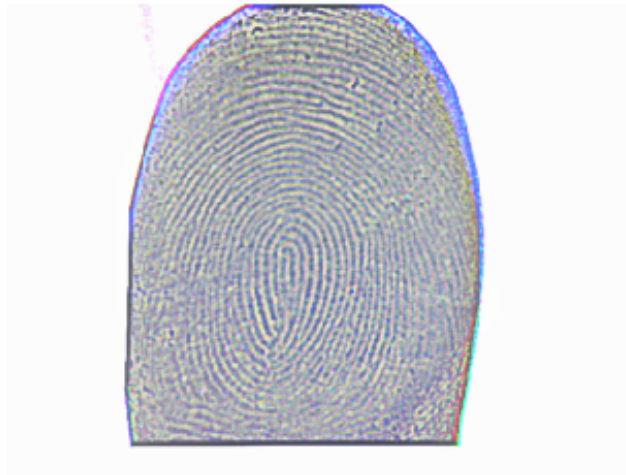# Dry Finger Skin

Raw Image   Binary Image

TIR

MSI

3 planes
mapped to
RGB

Can use the combination of TIR and MSI images to generate one composite fingerprint image even in adverse conditions

Biometric Determinations
Summary of Biometric Studies to Date

Office environment

- 602 samples taken on 15 people, 4 fingers each, 16 days

- **Standard fingerprint** sensor produced an equal **error rate of ~20%**

  - 4 individuals had dry fingers

- **Multispectral imager** produced an **error rate of 0.7%** using an off-the-shelf fingerprint software package

- MSI + TIR: EER=0.4%

TIR

MSI

Dry fingers

- Clay desiccant used to dry a finger used for 20-sample data collection

- **Standard fingerprint** sensor **failed to verify 17 / 20** images

- **Multispectral imager** correctly **verified all** images

Minimal contact

- 20 samples taken with finger lightly touching sensor

- **Standard fingerprint** sensor **failed to verify 19 / 20** images

- **Multispectral imager** correctly **verified all** images

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Summary

- Multispectral imaging of the finger provides a means to detect complementary biometric features of the finger
- MSI provides the ability to increase the <u>ease of collection</u> and <u>information content</u> of fingerprint images
- MSI+TIR development goal is improved security and usability

Usability

Multispectral Solution

Standard Fingerprint Offerings

Security
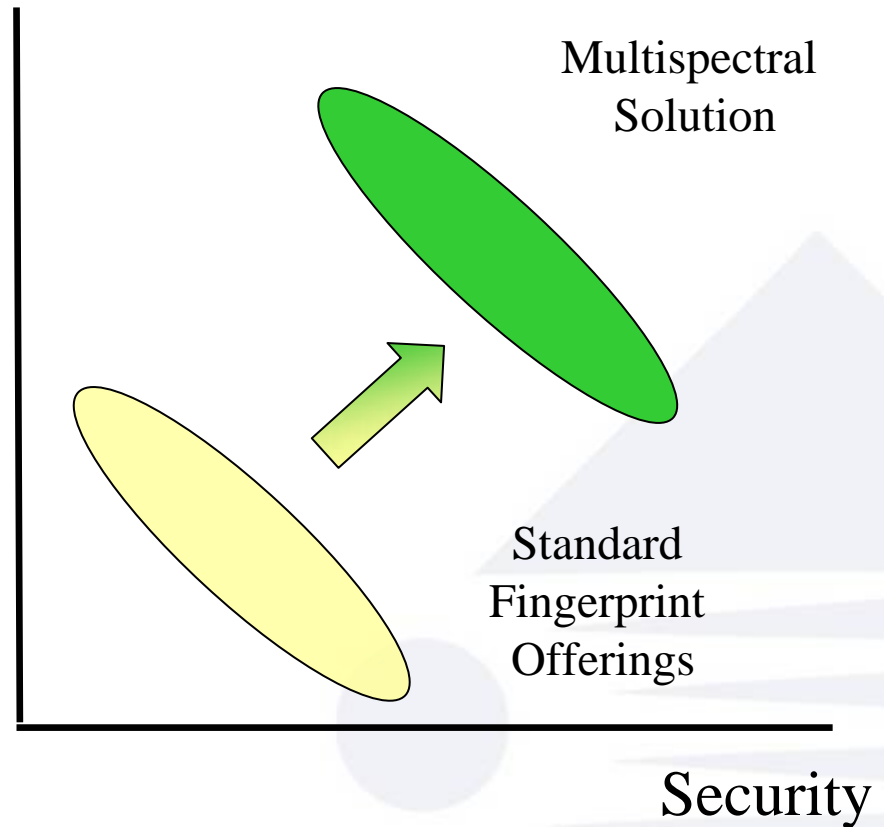
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Acknowledgements and Contact Details

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- Portions of this work are the result of a partnership between Lumidigm and Cross Match Technologies

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